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BELLCOMM, INC.

SUBJECT: Interim Report for AES Flight Mission Assignment Plan - Part VIII: Launch Facilities and Equipment (U)

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TECHNICAL MEMORANDUM

A. INTRODUCTION

This paper examines the launch facilities and equipment to determine their adequacy and/or feasibility of conversion to support the Apollo Extension System (AES). The examination is divided into three areas: Saturn IB launch complexes (Sec. B), Saturn V launch complex (Sec. C) and spacecraft checkout (Sec. D). Schedule requirements are related to existing and/or programmed launch facilities and equipment capabilities to determine their adequacy. Different methods of providing the Saturn IB AES capability are discussed, including operational constraints and major modifications and upgrading. Finally, facilities and GSE for spacecraft preparation and checkout are examined for their adequacy to support the proposed launch rate of eight spacecraft per year.

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B. Saturn IB

1. Schedule Requirements

The proposed launch schedule must be analyzed to determine the required number of launch pads and their configuration. For this, the minimum launch interval for an individual pad is first determined. Whereas the Saturn V is assembled and checked out in the Vertical Assembly Building (VAB) and transported to the launch pad in the assembled configuration, the Saturn IB is assembled and checked out on the launch pad. For the first Saturn IB's, 12 weeks are being allowed on the launch pad for assembly, checkout, and launch. It is felt that this assembly and checkout time for subsequent Saturn IB's can be gradually reduced, launch by launch, to approximately 9-1/2 weeks. In addition, time must also be allowed after each launch for pad refurbishment and necessary modifications. Therefore, to allow sufficient time for assembly, checkout, launch and refurbishment, launches from an individual pad must be planned with a minimum three months interval when successive launches are the same type vehicle (i.e., Saturn IB/Apollo or Saturn IB/Centaur).

From a launch facility viewpoint, the launches can be divided into two groups: Saturn IB/Centaur and Saturn IB/modified Apollo. The question of how many launch pads with the capability for each type launch must then be answered. The Saturn IB/Centaur launches are scheduled on a one month interval. Because of the three month pad interval, this alone dictates that there be two launch pads with Saturn IB/Centaur capability. An analysis of the proposed schedule reveals that there must also be two pads with Saturn IB/Apollo capability. The question then arises -- what is the present configuration of the Saturn IB launch complexes and the feasibility of providing the required capability?

Launch Complex 34 was originally constructed for the Saturn I, Block I, with dummy upper stage. It was later upgraded to Saturn I, Block II, capability as a backup pad for the Block II launches. It is presently being upgraded to Saturn IB/Apollo capability. Launch Complex 37B was originally constructed for the Saturn I, Block II, and will be upgraded to Saturn IB capability upon the completion of the Block II launches. Pad 37A was constructed for the Saturn I, Block II, launches, but because of a reduction in launch rates, was not outfitted. As discussed below, to further upgrade these pads to Centaur or dual capability will require considerable modification.

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2. Centaur Stage Addition

In providing the launch facilities and ground systems for the AES, the addition of the Centaur stage is the most significant single item. Ground systems to support a three stage launch vehicle rather than a two stage one must be provided. Some of the implications, in more detail, are as follows:

a. Service Structures. The present plans for Saturn IB modification do not include a service platform for the LEM, and there is some question as to whether it will be required. An additional service platform would definitely be required for the Centaur stage, which is at the same general height as the LEM. For a dual capability, the platform area and access arm to service the CSM must be maintained. The service platform system for the Saturn IB/Apollo is based on a space vehicle height of about 196 feet (excluding LES). Should the height of the Centaur payloads be greater than 30' (total space vehicle height 200') modifications to provide additional service access above the 200' level may be required.

b. Umbilical Arms. Umbilical arms are provided for the S-IB and S-IVB stages, IU and CSM of the Saturn IB/Apollo space vehicle. At least one additional umbilical arm must be added for the Centaur stage. For a dual capability, this added umbilical arm would have to be inactivated for a Saturn IB/Apollo launch as would the CSM umbilical for a Saturn IB/Centaur launch.

c. Mechanical Systems. The high pressure gaseous helium and nitrogen, LH_2, LOX, ECS, and other miscellaneous mechanical systems, including propellant loading computers and other associated electrical equipment, would have to be expanded to include the Centaur stage.

d. Electrical Support Equipment (ESE) and Instrumentation

Stage peculiar ESE for each stage is required for the vehicle preparation and launch and integration ESE is required to integrate this stage ESE. For example, the S-IVB stage ESE (20 racks) includes such items as networks, measurements, propellant dispersion and utilization, EBW monitor, component test, vehicle pressure, APS monitor and loading, hydraulic, engine, launch preparation and launch, and pneumatic panels, junction racks, and relay racks. The addition of the Centaur stage (which includes a second IU) would require the addition of a set of stage ESE for it. Also, the integration and power supply ESE (31 and 70 racks, respectively, for Saturn IB) would have to be expanded to include the Centaur stage. Much of the ground vehicle RF, TM and measuring instrumentation (127 racks for Saturn IB) is stage orientated-examples, service structure DDAS, DDCS and RACS. Additional equipment must be added to these systems to include the Centaur third stage. Also, all of this added ESE and instrumentation must be capable of being inactivated on a Saturn IB/Apollo launch. Cabling is a very significant item. In effect, for a dual capability, there would have to be two sets of cabling; one for Saturn IB/Apollo and one for Saturn IB/Centaur. To mix the type launches on a pad would require a rearrangement of cabling with each shift. For example, to provide the necessary cabling for a 37B dual capability would cost in excess of one million dollars. Extensions to the communication systems would also be required for the Centaur addition. Space in the LC-34 Launch Control Center (LCC) will be utilized for the Saturn IB/Apollo equipment and an extension to the LCC would have to be constructed to house the additional Centaur stage equipment. Also, LC-34 would require additional cableways for the new cables. The LC-37B LCC is larger than the one for LC-34 and is capable of housing the added equipment.

3. <u>LC-37A</u>

As noted in paragraph A-1, launch pad 37A was constructed for Saturn I, Block II, but not outfitted. Pads 37A and 37B were designed to use the same LCC and equipment, service structure, and facilities such as propellant storage. If LC-37B were converted to Saturn IB/Centaur capability, the additional effort needed to provide 37A as a second pad for this purpose would be to outfit the 37A pad proper. This would include such items as: equipping AGCS, including RCA-110A computer; instrumentation and power cabling; mechanical systems including such items as swing arms, ECS, and propellant distribution, and miscellaneous modifications. It has been estimated that the cost of facility modifications to configure pad 37A for the Saturn IB/Centaur would be about three million dollars. This includes such items as U/T modifications for swing arms, cabling, pipe chases, and communications, but not the mechanical and electrical equipment. Of these, cabling is the most significant item. Use of LC-37A for the Saturn IB/Centaur would have the advantage of having to provide only one set of LCC Centaur stage equipment, concentrating Centaur operations in one area, and having to configure only one LCC for dual operation. If the Saturn IB/Centaur Voyagers were to be scheduled from 37A and 37B at a one month interval, availability of the common service structure would be a constraining factor, as would use of the common LCC. If an attempt were made to simultaneously erect vehicles on 37A and 37B, one vehicle would be unprotected in the case of high winds which condition is not likely to be accepted. Use of the common LCC is a restraint in that the LCC equipment can work only one vehicle at a time. Shifting from 37A to 37B, or vice versa, requires time to reconnect the cabling. Therefore, successive launches of the same type vehicle from 37A and 37B should not be scheduled on less than a 10 weeks interval. This precludes launch of two Centaurs from LC 37A and LC 37B at a one month interval.

4. Payload GSE

a. Modified Apollo. The Saturn IB/modified Apollo launches of the AES do not represent a radical or abrupt change in flight hardware from those Saturn IB/Apollo (MLL) launches which include a LEM. The mobile concept, roll on - roll off the pad, is used for the Apollo servicing equipment. However, it is expected that it would evolve with the payload development and not be a constraining or pacing item. The Apollo pad checkout will be controlled by the ACE equipment in the O&C building and carry-on equipment aboard the CSM. This equipment can be mission influenced. But again, it is expected that it would evolve with payload development and not greatly affect the launch complex except for possible additional cabling. The latter, if required, could be added.

b. Scientific Payloads. GSE will be required to prepare the scientific payloads for launch. This is not considered a problem or restraining area. For example, Pegasus experiments are included in the Saturn I, Block II, launches.

5. Launch Complex Modifications

It is estimated that 6 to 7 months would be required to convert LC-34 and 37B to a dual capability. Work on LC-34, such as LCC extension and cableways, would need to precede this modification period. An additional four months would be required after modification to checkout the GSE and assemble the next flight vehicle. Therefore, a period between launches of 10 to 11 months will be required for modification to Centaur capability.

6. Reconfiguration time

In the absence of a detailed analysis of the time required to reconfigure a launch complex from Saturn IB/Apollo to Centaur, or vice versa, it is assumed that the reconfiguration can be done in not less than one month. This month must be added to the pad turn-around time, resulting in a 4 month launch interval for LC-34 and 37B when a change in configuration is involved.

C. Saturn V

1. Launch Facilities

a. General. The proposed schedule shows a buildup of the Saturn V launch rate until a sustained launch schedule at two month intervals is obtained in CY-1970. Two launch pads, three launcher umbilical towers (LUT), two launch control centers, and two vertical assembly building (VAB) high bays are presently programmed for construction and/or outfitting. The question then arises - are these programmed facilities capable of supporting the proposed launch rate?

b. Operating Times. The nominal planned schedule for Saturn V LC-39 operations is as follows:

	Working Days
VAB High Bay	45
Launch Pad	13
LCC Firing Room	58
LUT	58
MAT	11

This schedule is based on a 5 day work week, or 12 weeks from arrival of flight hardware at the VAB until launch. However, this nomimal schedule does not allow for major trouble or prolonged adverse weather being encountered. Although a 45 work day use period is shown for the VAB high bay, the bay would be kept clear and in a condition to receive the LUT/space vehicle from the pad in case of a major storm, malfunction or difficulty necessitating its return.

c. Refurbish and GSE Checkout. Elements of concern are the LUT and launch pad which are exposed to launch damage. The necessary refurbish operations following a normal launch are expected to be limited to superficial maintenance and minor repairs on launch accessories and control electronics. Projected times are 3 weeks for the LUT and 2 weeks for the launch pad. If major LUT damage were encountered, or if necessary to maintain the schedule, the third LUT could be placed in service.

d. Launch Rate. Except for joint use of the crawler-transporting and mobile arming tower, the LC-39 consists of two independent launch facilities. Considering the projected assembly, checkout, launch, equipment turn-around time, and allowance for unforeseen delays, each of the facilities could launch on a sustained four months interval, or on a 2 months average interval for the complex. A higher launch rate should not be planned for LC-39 until actual operating experience is obtained.

2. GSE

The Saturn V AES missions do not represent a radical or abrupt change from the MLL program. It is therefore expected that the Saturn V GSE will evolve with the launch vehicle and payload changes as for the Saturn IB. The GSE for the Saturn V AES is not considered to be a restraining factor.

D. Spacecraft Schedule and Requirements

General

This section examines in short the principal SC facilities and GSE as to their capability for preparing 8 SC/year for launch.

The information presented constitutes an estimate derived from the MSC/FO test flow plan and some informal discussions held with personnel from MSC/FO. The time estimates are based on a successful flow plan, i.e., no failures in flight hardware, GSE or facilities.

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Introduction

The items, believed to be pacing the SC launch preparations and which are examined as follows, are the high bay of the O&C building, ACE-SC and complex 16.

The O&C high bay accommodates the SC assembly, the integrated systems tests, the altitude chamber tests, simulated launch countdown and flight tests. The high bay contains two test cells. One of these contains the polarity checker and hence does not provide sufficient space for a completely assembled SC (CSM/LEM/SLA). Otherwise, two SC's could be prepared simultaneously.

ACE-SC is the basic test equipment used for the SC test operations. It is assigned to a particular SC (CSM or LEM) and its associated GSE during a specific test phase.

Complex 16 is used for static firing of the SPS, LEM AS and DS. Two separate test stands will accommodate the SM and LEM static firings.

Schedules

Total time for high bay test operations is some 43 days/S/C. Since integrated CSM/LEM/SLA testing is estimated at some 10 days, and only one test cell can accommodate these latter tests, two full S/C's can be prepared in 53 days. Assuming a 5 day week the capacity is .19 S/C/week or 10 S/C year. Assuming a 7 day week the capacity is .26 S/C/week or 13.5 S/C/year.

The actual test time, involving ACE-SC, comprises 25% of the total time for test operations. If 8 launches are scheduled per year, each ACE-SC station has to handle 4 SC's (CSM or LEM). The total time for preparing a S/C for launch is 93 days. Assuming an even distribution of launches during a year, not more than 2 S/C's have to be handled simultaneously by ACE-SC. Turn around time for ACE-SC from one SC to another is less than 20 minutes. Assuming a two (2) shift work day (16 hrs) to accomplish the test operations, ACE-SC utilization on two SC's requires 8 hrs (25%) for test operations and 40 minutes to turn around twice. Assuming a one (1) shift work day (8 hrs), ACE-SC utilization requires 4-2/3 hrs accordingly. Even taking into account that other time requirements exist for ACE - S/C, such as for maintenance, off-line data processing, etc. ACE-S/C does not seem to constitute a pacing item.

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Complex 16 will accommodate the SPS and LEM AS/DS in two separate test stands. Static firing of the SPS and refurbishing of the test stand does not require more than 10 days. Similar requirements exist for the LEM AS/DS static tests. Hence, Complex 16 does not constitute a pacing item.

A major problem, however, will be the manpower requirement. It is estimated that during the last week befor launch, the manpower required to ready one S/C is 500 men. Since most of these men perform a task which requires a great deal of experience in a particular area, the pacing item might arise from this requirement.

Conclusion

It is believed that the MSC facilities and equipment can prepare 8 S/C/year for launch. A major problem, however, seems to exist in the manpower requirement. This problem needs special attention.

E. Summary

1. Saturn IB. Considering necessary time for space vehicle assembly, checkout, and launch and launch pad refurbishment and reconfiguration, launches from an individual pad should not be planned on less than a three-month interval when there is no change in launch vehicle type and four months when there is a change in vehicle type. An analysis shows that to meet the proposed launch schedule and to provide backup capability, two launch pads with Saturn IB/modified Apollo and two with Saturn IB/Centaur capability will be required. Both LC-34 and LC-37B are presently programmed to be converted to Saturn IB/Apollo capability and will thus meet the Saturn IB/Apollo launch requirements.

Different launch complex configurations to meet the Saturn IB/Centaur requirements were considered. Among those were the conversion of LC-37A to Centaur capability and LC-34 and LC-37B to dual capability. The use of the 37A-37B common service structure and Launch Control Center (LCC) imposes a constraint which would preclude Saturn IB/Centaur launches from them at less than 10 weeks intervals. Although desirable from the standpoint of concentrating Centaur operations at one launch complex and having only one pad with a dual capability, this configuration will not support the proposed launch schedule.

To meet the proposed launch schedule, both LC-34 and LC-37B must be converted to dual Saturn IB/Apollo and Saturn IB/Centaur capability. Major conversion requirements are shown in Table I. LC-37A would not be upgraded. As LC-34 and 37B are independent of each other, this configuration would also permit an even shorter interval between two successive launches than stipulated in the proposed schedule.

2. Saturn V. Two vertical assembly building (VAB) high bays, two LCC firing rooms, two launch pads, and three launcher umbilical towers (LUT) are presently programmed for construction and/or outfitting. These facilities can support the maximum proposed Saturn V launch rate of 6/year at two months intervals. A higher launch rate should not be planned for the programmed facilities until actual operating experience is obtained. This does not preclude a shorter interval between two successive launches. However, should the restraint be imposed that a specific launch meet a specific launch window, it can be expected in practice that a portion of the launch complex will at times be idle possibly resulting in a lowering of the launch rate of six/years.

3. Payload GSE and Manpower. It is expected that the payload GSE and improvements thereof will evolve with payload development and not be a constraining factor in meeting the proposed AES schedule.

The spacecraft preparation and checkout GSE and facilities at KSC are capable of supporting the proposed maximum launch rate of eight/year, if no major unforeseen spacecraft problems are encountered. However, manpower availability for spacecraft preparation and checkout is a problem area and will require special attention. Also, this assumes that major spacecraft modifications will be done elsewhere.

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TABLE I

LC-34 and 37B Conversion Requirements for Dual Capability

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	LCC Extension	S/S Modifications	S/S Centaur Equipment	AGCS Added Centaur Equipment	LCC Added Centaur Equipment	Centaur Cabling	Centaur Swing Arms	Facility Modification Cost (Does Not Include Equipment)
LC-34	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Not available but will be more than for 37B
LC-37B	No	Yes	Yes	Yes	Yes	Yes	Yes	$2,000,000

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